March 2, 2020

Updated April 9, 2020

MEMORANDUM FOR: NCEP Model Implementation Scientific Review Team

FROM: Vijay Tallapragada, Chief
Modeling and Data Assimilation Branch
NCEP Environmental Modeling Center

SUBJECT: Proposed Implementation of Global Ensemble Forecast System, Version 12.0

The Environmental Modeling Center (EMC) has proposed the implementation of Version 12 of the Global Forecast Ensemble System (GEFS). Changes and associated expected benefits of the GEFS model upgrade include:

Changes to the model core, resolution, and ensemble membership:

- use of the Finite Volume 3 (FV3) core
- increases of the horizontal resolution to C384L64 (approximately 25 km). Also, the current GEFS truncates the resolution after day 8; GEFSv12 will maintain a constant horizontal resolution throughout the forecast
- the number of ensemble members is increased from 21 to 31
- the forecast length 00z cycle is extended to 35 days

Changes to initialization:

- replacement of the specification of sea-surface temperatures (SST) with a two-tiered approach using a Near-Surface SST scheme (which allows the temperatures to vary throughout the day) as the base state and adding terms representing climatological tendency and bias-corrected forecasts from the Climate Forecast System (atmosphere-ocean coupling).
- the model uncertainty is now represented by a stochastic physics approach that combines 5-scale stochastically-perturbed physics tendencies (SPPT) with reduced stochastic kinetic energy backscatter (SKEB) scheme.

Other changes to forecast model:

- the Zhao-Carr microphysical scheme is replaced by the GDFL scheme
- updates to the land-surface characteristics for grassland and cropland categories
- improvements to the convective scheme and convective gravity wave drag
- revised bare soil evaporation scheme
- new parameterization of middle atmospheric water vapor photochemistry
- upgraded surface layer parameterization
- corrected ground flux calculation over snow cover

- integration of Global Wave Ensemble System (GWES) into the GEFS (one-way coupling)
- add a second control member running the GEFS-aerosol forecast to replace the current NEMS GFS Aerosol Component (NGAC). This member includes a version of the Goddard Chemistry Aerosol Radiation and Transport (GOCART) model.

Changes to the wave component

- global spatial grid resolution increased from ½ to ¼ degree
- extended forecast range, from 240h (10 days) to 384h (16 days)
- increased from 21 to 31 members
- improved physics: source-term coefficients tuned using objective framework
- increased wind field intake stride from 3h to 1h due to coupling

Changes to products:

- addition of 76 parameters
- addition of station time series BUFR output for each member and mean
- new products to cover the extension of the 00z cycle to 35 days
- new products at 0.25 degree resolution for selected surface variables
- elimination of 1.0, 1.25, and 2 degree GEFS products
- increased resolution of global wave grid output products from ½ deg to ¼ deg
- updated wave parameter grib2 encoding to reflect most recent WMO tables
- addition of mean zero-crossing wave period and data from a third swell partition to wave gridded products

Expected benefits:

- overall improved model skill
- increased and more meaningful spread
- overall improvement in tracks for tropical cyclone forecasts
- extension to 35 days (once per day) to assist with longer-range forecasting
- for aerosols: increase in horizontal resolution to around 25 km, increase to 4 cycles per day with 5-day forecasts, and improved smoke and dust emission modules and predictions
- wave component: improved skill scores due to improved physics tuning, to higher spatial grid resolution, and to higher stride of atmospheric input data

Validation and verification:

The EMC Model Evaluation Group's (MEG) web site with links to all verification and validation materials is https://www.emc.ncep.noaa.gov/users/meg/gefsv12 Due to resource constraints, there is no real-time GEFSv12 parallel for the full system. Instead, retrospective runs covering a 2.5 year period from July 2017 to November 2019 were made for the weeks 1-2 atmospheric components. The GEFS-Aerosol member is run

daily out to five days in near real-time, and retrospectives cover March 2019-February 2020. The GEFS-wave component retrospective covers a 1-year period from Dec 2018 through Nov 2019. Reforecasts covering a 30 year period were made for the weeks 3-4 atmospheric components.

A full set of statistical verification metrics comparing the performance of GEFSv12 with GEFSv11 can be found, along with links to verification of tropical cyclones, waves, and aerosols under the verification section of the MEG GEFSv12 evaluation page: https://www.emc.ncep.noaa.gov/users/meg/gefsv12/. Graphical imagery comparing the retrospective runs to the atmospheric component of the operational GEFS for a set of 44 selected cases (1-10 day forecasts) can be found on an EMC web page at https://www.emc.ncep.noaa.gov/users/meg/gefsv12/retro/.

The MEG will present reviews of the atmospheric cases and statistics at weekly webinars during the evaluation period; these presentations will be uploaded to the primary evaluation web page. Please contact geoffrey.manikin@noaa.gov to be added to the listserv for announcements of MEG webinars.

Request for Evaluation

There are four components of the evaluation:

ATMOSPHERIC WEEK 1-2

All Regions (Eastern, Southern, Central, Western, Alaska, and Pacific) of the National Weather Service as well as the Weather Prediction Center (WPC), National Hurricane Center (NHC), Aviation Weather Center (AWC), Storm Prediction Center (SPC), and Ocean Prediction Center (OPC) are listed as being primarily responsible for this evaluation. All other Service Centers, government agencies, or private companies not listed above are optional.

ATMOSPHERIC WEEK 2-4

The Climate Prediction Center is the primary evaluator of this aspect of GEFSv12 performance. (EMC will contact CPC directly.)

WAVES

The Ocean Prediction Center (OPC), the National Hurricane Center (NHC), NWS Marine Weather Services, the Fleet Numerical Oceanography and Meteorology Center (FNMOC), and the Environment and Climate Change Canada (ECCC) are primarily responsible for this evaluation. All other Service Centers, NWS Regions, government agencies, or private companies not listed above are optional.

AEROSOLS

The National Environmental Satellite, Data, and Information Service (NESDIS), the NCEP centers, the NOAA ARL (Air Resources Laboratory), the Department of Defense, the Environmental Protection Agency, and the NOAA Office of Water and Air Quality are primarily responsible for this evaluation. A small subset of individual users who work with the EMC Air Quality team will also be contacted to participate.

The scientific evaluation of the GEFS model upgrade proposed for implementation will be based on the set of retrospective and reforecast experiments conducted by EMC. Recommendations will be presented to the NCEP Director at the conclusion of the evaluation period, and a formal decision will be made. If approved, code will be delivered to NCO for their construction and testing of the parallel system. A final 30-day parallel by NCO will assess only IT evaluation and model stability. Implementation of the GEFSv12 package is currently targeted for September 2020.

The evaluation period for the GEFSv12 upgrade has begun today and will run through April 10, 2020. Participants need to complete the relevant Google form (linked at the end of this document) **no later than April 27, 2020**. Using the link to any of the forms in the next section, please indicate the overall performance of the product, with any additional comments on specific cases with noteworthy positive or negative performance. Any feedback you wish to provide during the evaluation period can be sent to any of the contacts listed in the next section. The MEG will host a webinar on April 30, 2020 to review the evaluations and address any outstanding issues. Based on the outcome of that webinar, EMC and NCO will prepare a recommendation for the NCEP Director.

Model Implementation Subjective Evaluation Report

At the end of the evaluation period, one person from your center, region, agency, or company should complete from the following forms, the ones that are relevant to the role(s) your center or agency is playing in this assessment:

Atmospheric weeks 1-2
https://docs.google.com/forms/d/1kRFBILWGCVK95rqdR12cnsFWUFUE43RjR7Bx0b0LxEs/edit

Wave model component
https://docs.google.com/forms/d/1qSpbQ7wQuXxLDU9t1UjiJ9lX5-1QRpx8GggxYxin2d0

Aerosols component
https://docs.google.com/forms/d/1cpGp1m-dDIyZGY8RqiuQRJauurtS9sshADnjXHiw_Ro/edit?ts=5e5d6e48

Points of Contact

for major concerns: Vijay.Tallapragada@noaa.gov (EMC)

for issues/questions related to evaluation: Geoffrey.Manikin@noaa.gov (EMC)

for questions about the configuration of the GEFS system: Yuejian.Zhu@noaa.gov (EMC)

for questions about the aerosols component: Jeff.McQueen@noaa.gov (EMC)

for questions about the waves component: Henrique.Alves@noaa.gov (EMC)